EMTiming Project

A Proposal to Add Timing Information into the Readout of the CDF Central and Plug Electromagnetic Calorimeters

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Why do we need EMTiming?

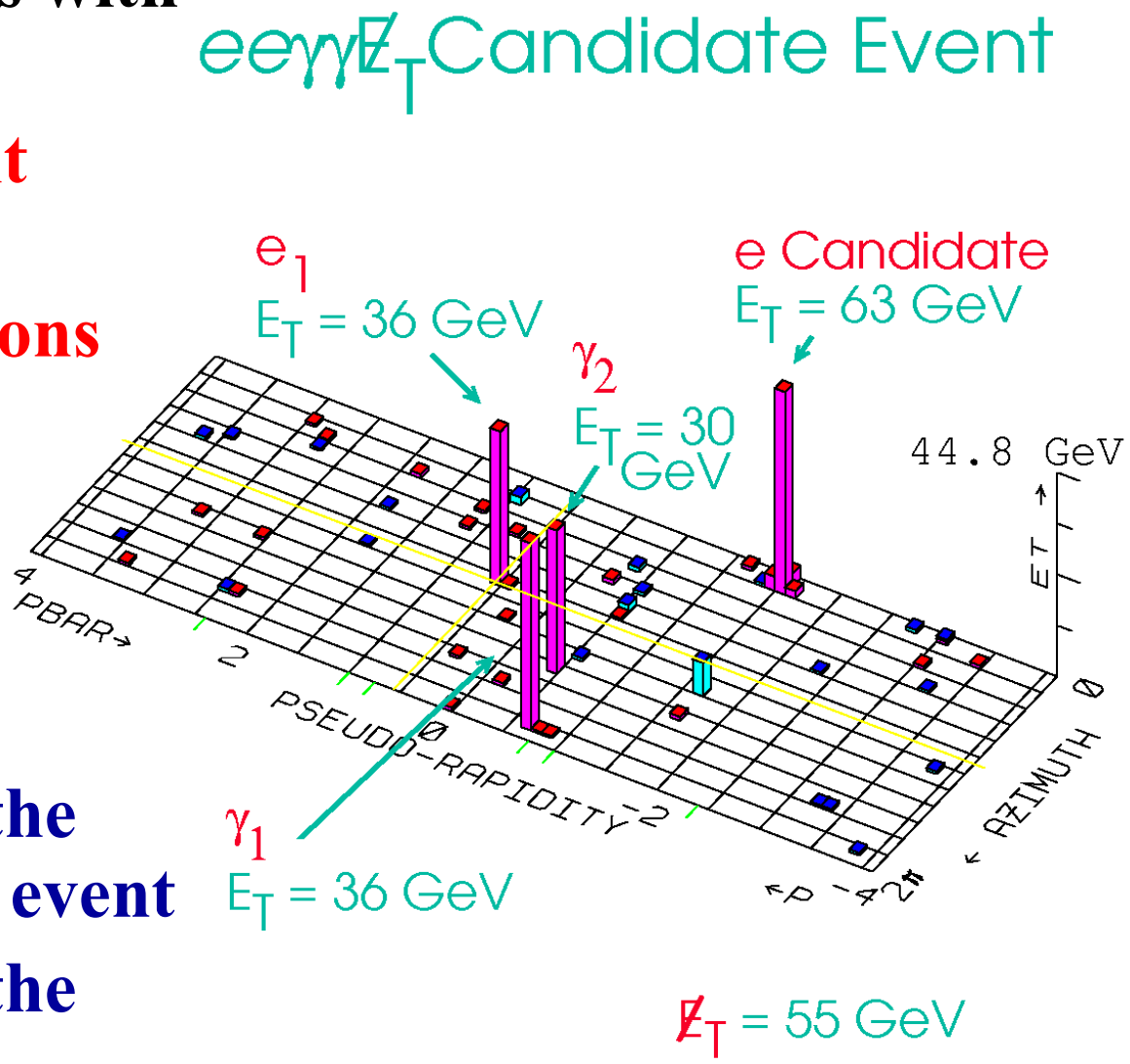
Two primary reasons to add timing to the EM Calorimeter:

1. **Would reduce the cosmic ray background sources and improve the sensitivity for high-P_T physics such as SUSY, LED, Anomalous Couplings etc. which produce γ+Met in the detector**
2. **Would provide a vitally important handle that could confirm or deny that all the photons in unusual events (e.g. CDF eeγγ+Met candidate event) are from the primary collision.**

Physics Motivation

Types of high P_T physics with photons and MET

- **SUSY (N_2 γN_1, light gravitinos)**
- **Large Extra Dimensions**
- **Excited leptons**
- **New dynamics**
- **V+Higgs V+$\gamma\gamma$**
- **W/Z+γ production**
- **Whatever produced the ee$\gamma\gamma$+MET candidate event**
- **Whatever produced the CDF $\mu\gamma$+Met excess**



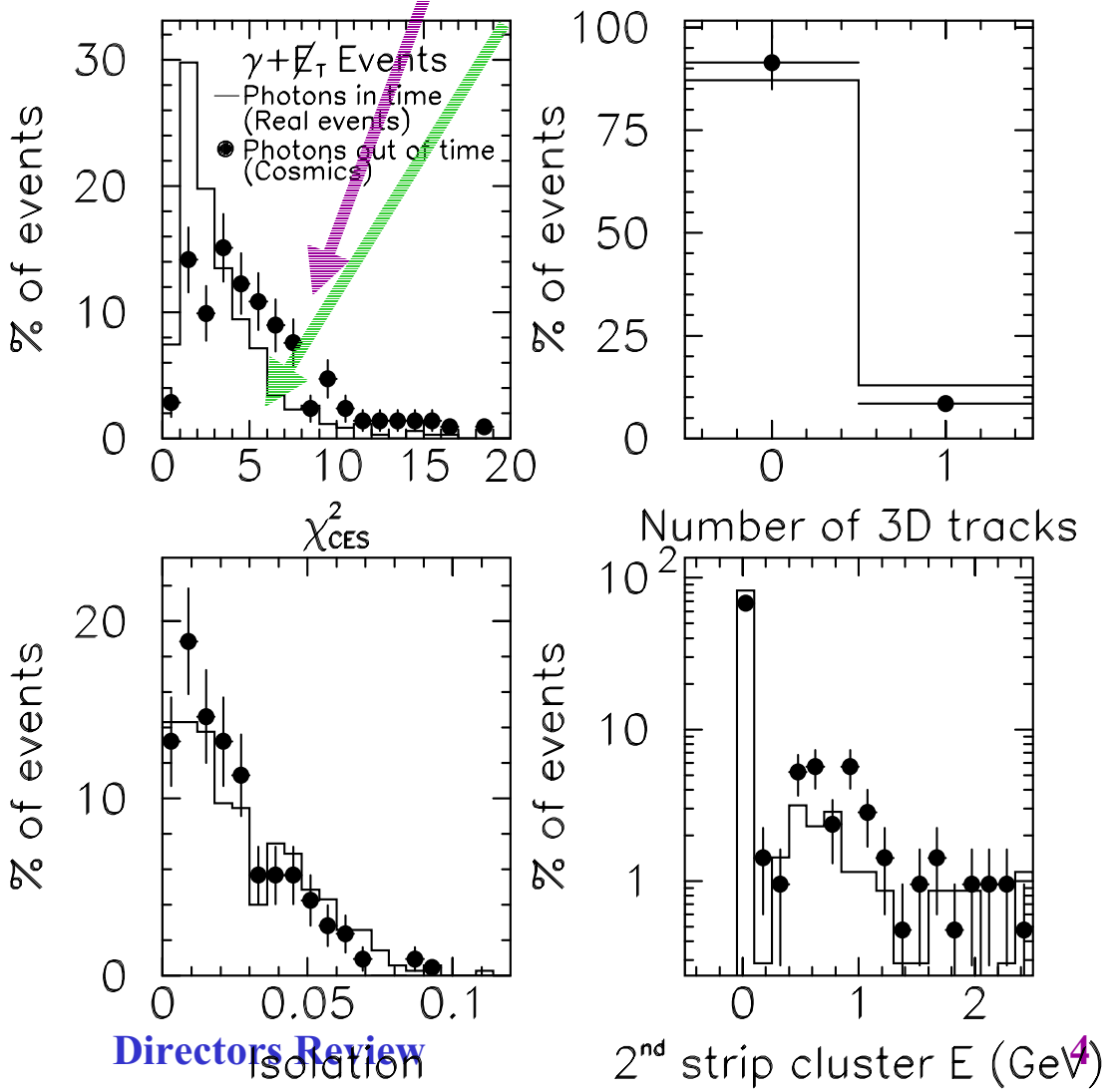
Real photons vs. Cosmics

Problem: Cosmic rays enter the detector and fake a photon (+Met)

- **Question:** Can't you just make ID cuts and get rid of the cosmic ray backgrounds?
- **Answer:** Photons from the primary event, and photons from cosmic rays look very similar in the CDF calorimeter. Many are real photons.

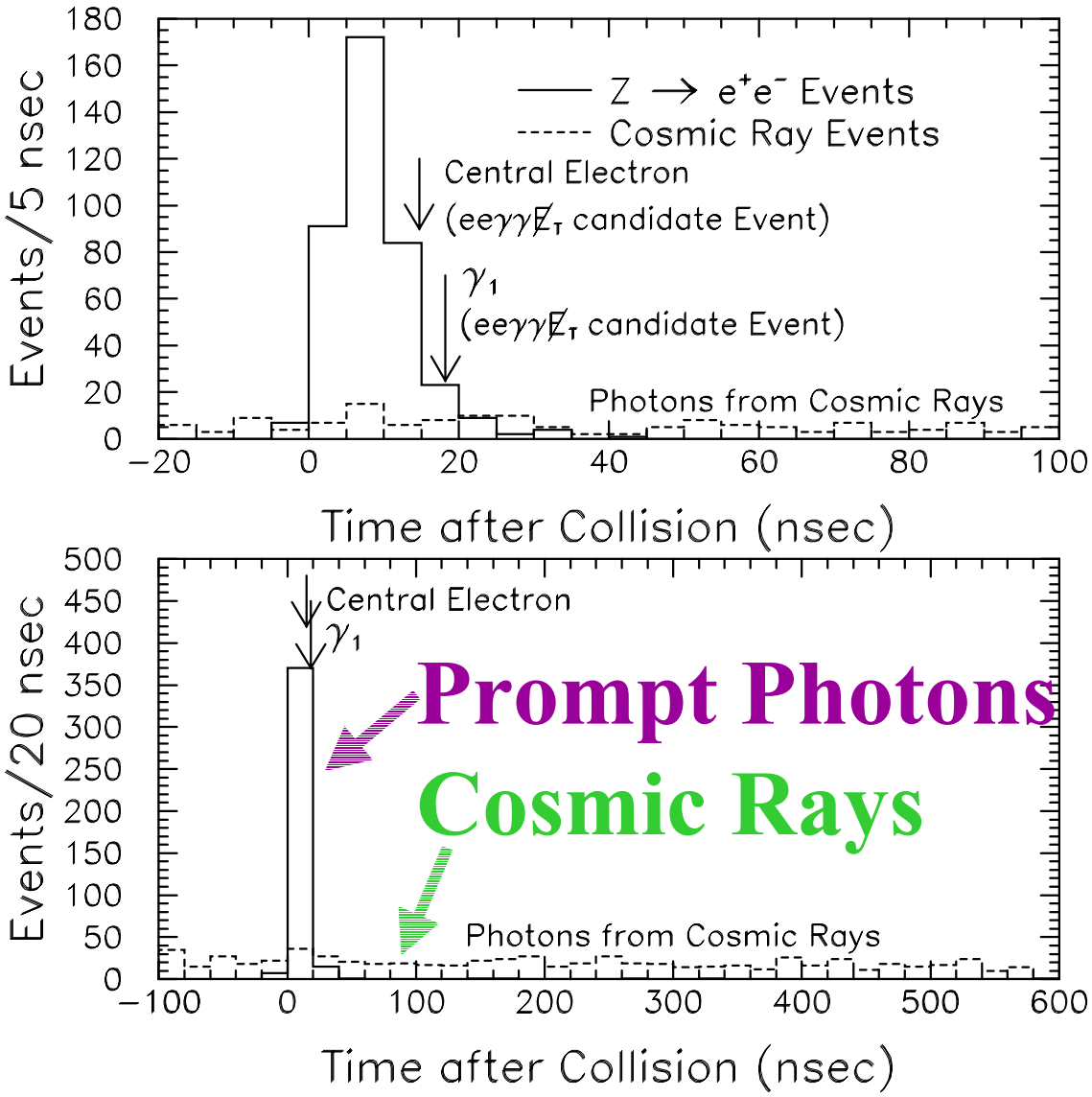
Points: Photons from Cosmics

Solid: Photons from collisions

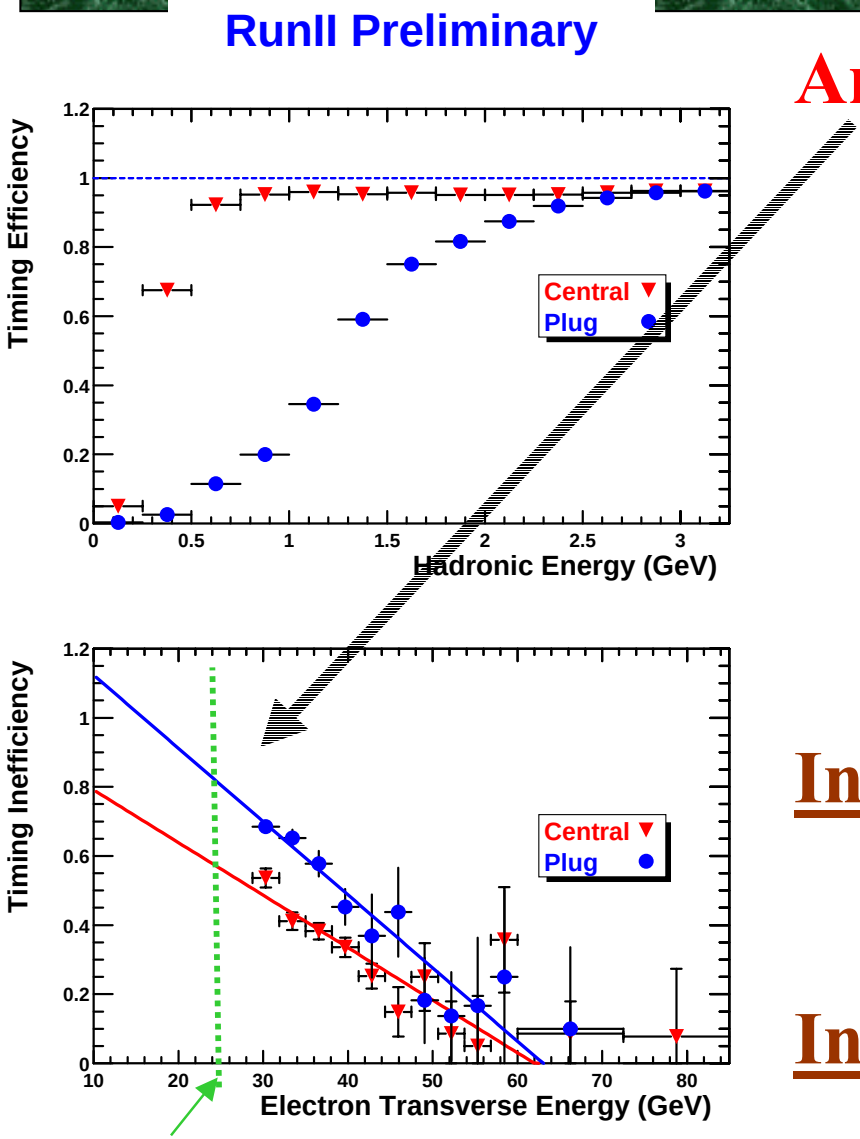


Timing in the Calorimeter

Timing in the Hadronic Calorimeter (HADTDC system) can help distinguish between photons produced promptly and from cosmic rays



Problem with HADTDC Timing



An EM shower needs to leak into the hadronic section of the calorimeter to have timing

HADTDC system is very inefficient for low E_T

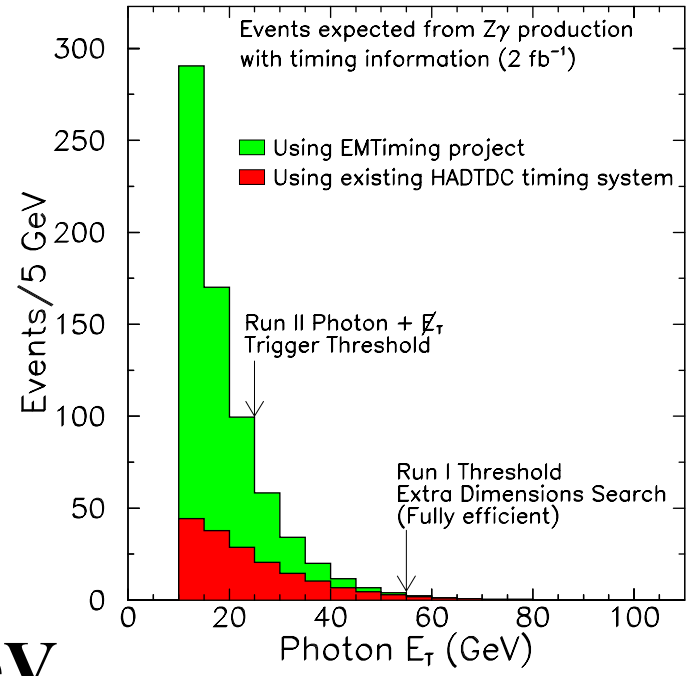
Requiring timing for a photon gives a bias toward fake photons from jets

In Run I: Expected ~1.4 of the 4 EM objects to have timing. Only 2 did (both were in time)

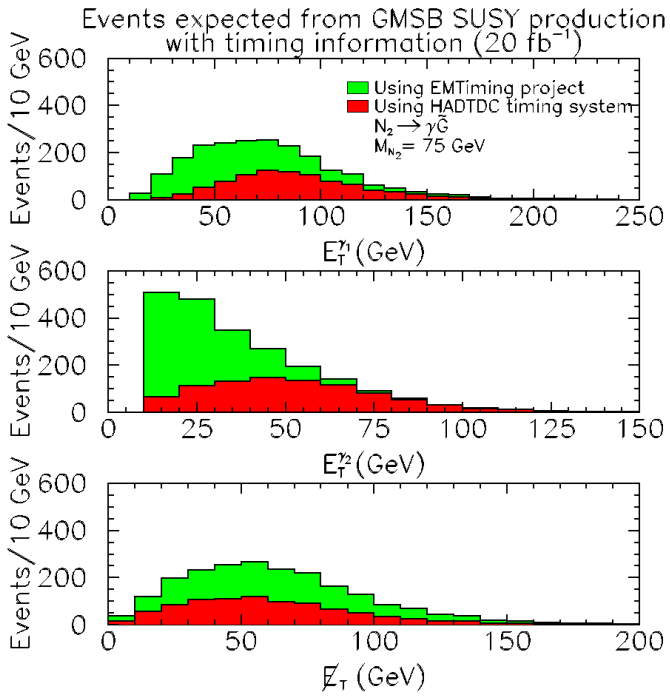
In Run IIa: Only ~5% of eeγγ+Met events would have timing for all objects.

How EMTiming Would help

- Give timing for all useful photons at ~100% efficiency
- Example using known physics Zγ:
  - –HADTDC: Not fully efficiency until above 55 GeV
  - –EMTiming: Use all events from the 25 GeV trigger



Zγ Example



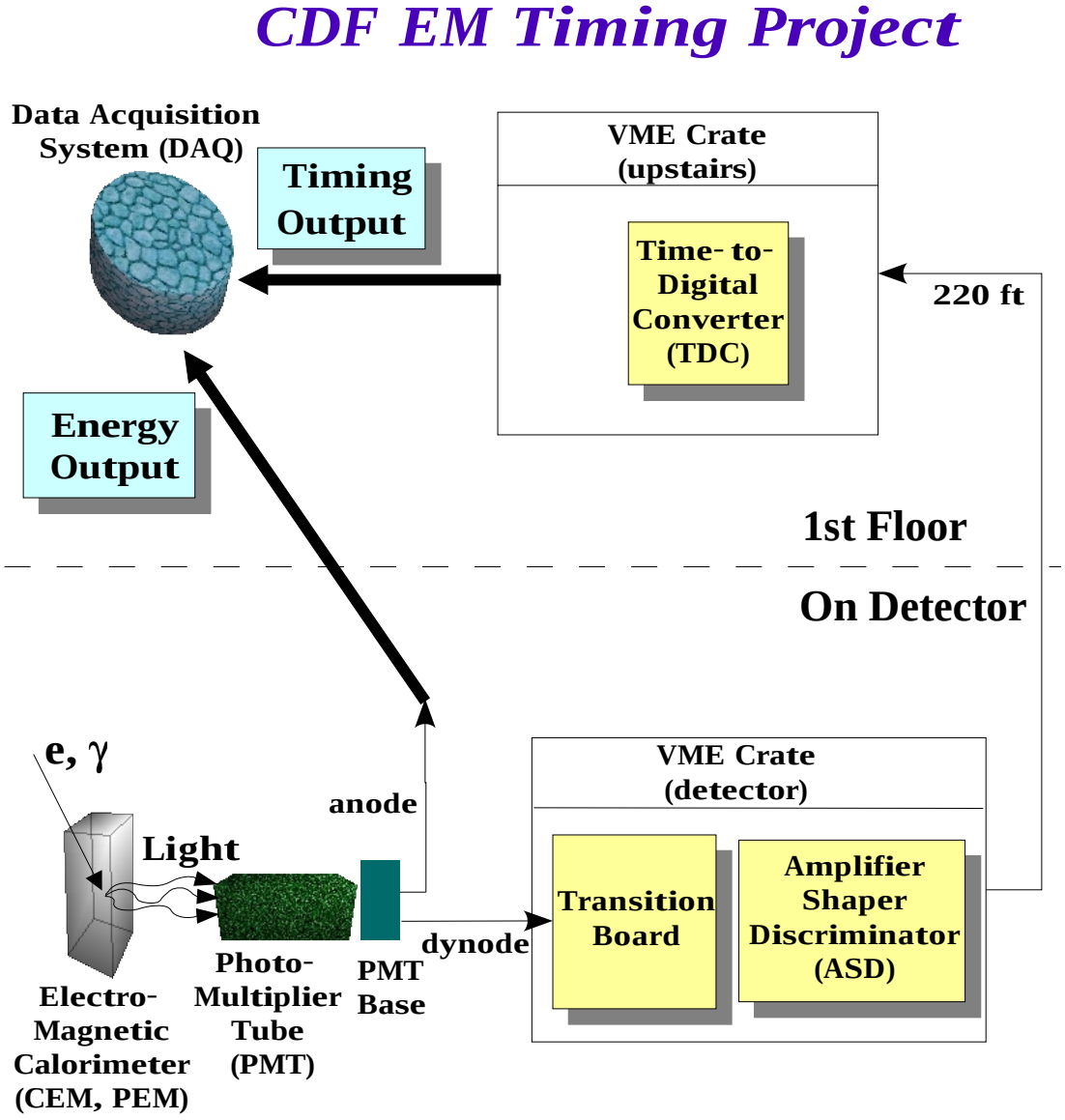
SUSY Example

$$\Rightarrow \frac{\text{EMTiming Acceptance}}{\text{HADTDC Acceptance}} = \frac{\text{Events above 25 GeV}}{\text{Events above 55 GeV}} \approx 30$$

Hardware for EMTiming Project

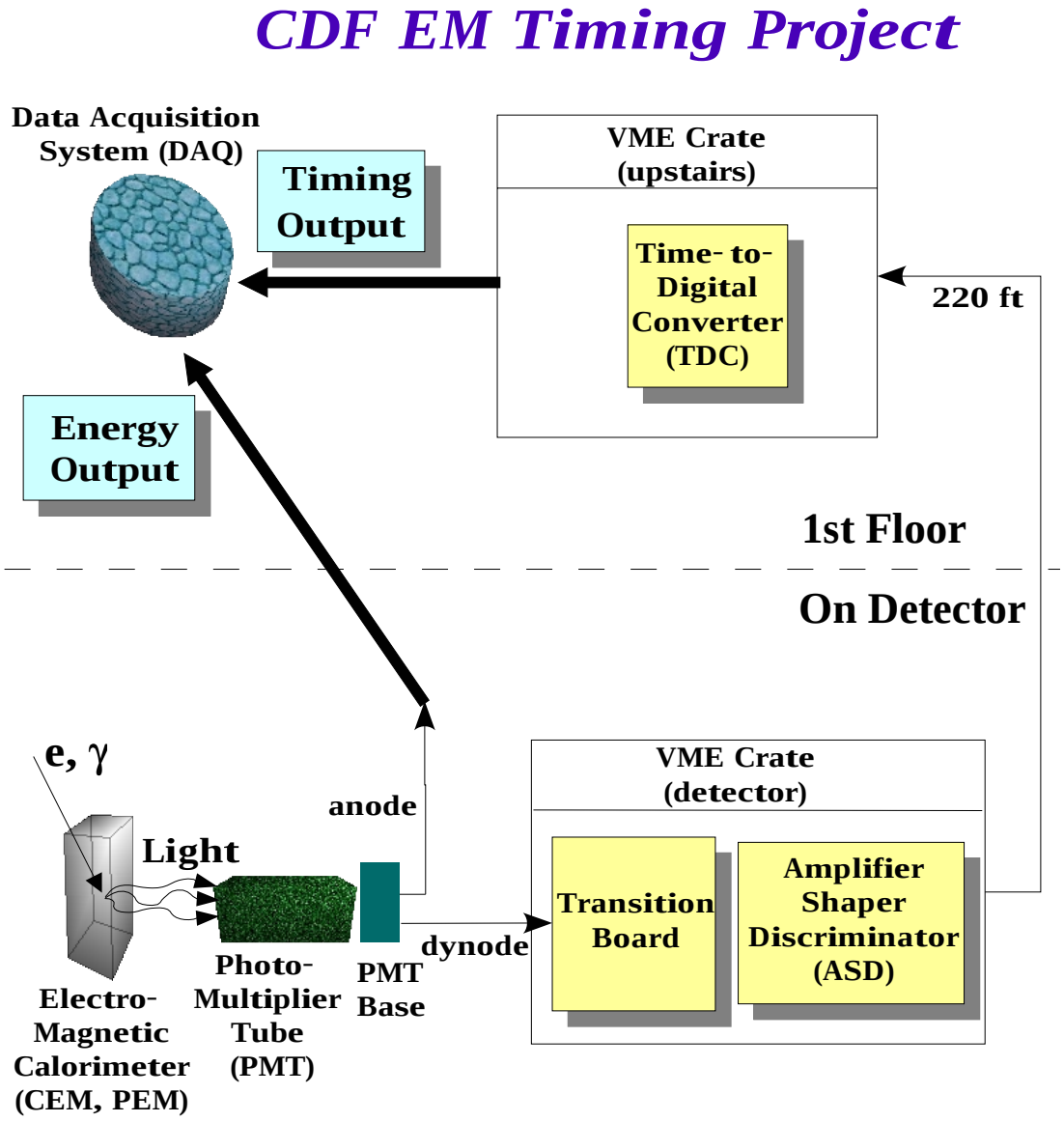
Add TDC readout to CEM and PEM

- Hardware is virtually identical to HADTDC system
- Small R&D costs
- Small technical risks



Project Tasks and Hardware

- **Modify 960 CEM bases to have readout**
  - PEM bases already readout-ready
- **Build more Transition boards/ASD's**
  - Space in crates on first floor already exists
- **Recycle small-via TDC's**
  - Recycle crate and tracer, purchase new off the shelf power supply and processor
- **Cables and connectors**



Parts and Cost

- **M&S costs for this project would be covered by outside sources/grants**
  - **Texas A&M (TAMU)**
  - **University of Chicago**
  - **INFN**
- **Will recycle much of the parts**
  - **Small-via TDC's**
  - **Base Transition board cables**
  - **Spare crate and Tracer**
  - **Much of the PEM dynode-Transition board connectors**

Parts, costs and who pays

CEM	Parts & Spares	TAMU	Chicago	INFN	Recycled	Total
Connectors	~3000	$18k				$18k
PMT TB Cable	~1000				$3.5k	$3.5k
Transition Board	27			$13.2k		$13.2k
ASD	27			$40.5k		$40.5k
ASD TDC Cable	32		$13.9k			$13.9k
TDC	7				$33.6k	$33.6k
Crate and Tracer	1 & 1				$10k	$10k
Power Supply and Processor	1 & 1	$5k				$5k
PEM						
Connectors	~1000	$9k				$9k
PMT TB Cable	~1000				$2.9k	$3.5k
Transition Board	18			$8.9k		$8.9k
ASD	18			$27k		$27k
ASD TDC Cable	20		$8.7k			$8.7k
TDC	5				$24k	$24k
Total pre-Contingency costs		$32k	$22.6k	$89.6k	$76.7k	$220.8k

Assembly and Installation

Responsibilities:

- **Overall system, R&D, testing and readout:** TAMU
- **Bases and cables:** TAMU and UC
- **ASD and Transition boards:** INFN
- **TDC/Crates:** TAMU and w/assistance from UM

Activities before Run IIB

Most activities are manpower intensive (~336 man-days) and will be done mostly by University physicists and techs

- **Prior to Run IIb Shutdown**
  - Collect parts for cables and assemble
  - Construct transition boards and ASD's
  - Assemble upstairs TDC crate
- **During small shutdowns (if possible)**
  - Install PMT Transition board cables
  - Install transition boards, ASD and dress cables
- **Run IIb shutdown**
  - Modify bases
  - Install remaining cables including cables upstairs
    - Requires FNAL tech assistance
  - Test

See next talk for more detailed schedule

Descoping/Simplifying possibilities

1. **Passive splitting of anode lines in CEM**
2. **Instrument only the CEM**
3. **Instrument only PEM (does not require PMT base modification)**

Benefits vs. Cost/Risk

- **Benefits:** Important improvements in acceptance and robustness for difficult photon searches
- **Costs:** Small project costs (<5% of Run IIb budget), no M&S outlay from FNAL
- **Risks:** Primary risk is currently the schedule. What if we don't finish the modifications on time? Modular design of system (and base modifications) make it such that if we don't hook up the system, it doesn't affect the current readout. If we don't finish on time, we will simply not hook up the system so we don't affect the rest of the physics program.

Summary

- **EMTiming would significantly enhance searches for new high P_T physics in photon final states**
- **EMTiming would give a vital handle as to whether E_T photons are from the primary collision in unusual events**
- **Small costs which are well understood**
  - **No hardware costs to FNAL**
  - **Significant percentage of cost is in recycled parts**
  - **Simply following existing designs**
- **Minimal R&D and technical risk**